

# FUNDAMENTALS OF PHYSICS

Second Edition

Halliday

Resnick

# BEST AVAILABLE COPY

This book was printed and bound by Von Hoffman Press. The designer was Joe Gillians. The manuscript was edited by Deborah Herbert and Eugene Patti. The drawings were designed and executed by John Balbalis with the assistance of the Wiley Illustration Department. Lilly Kaufman supervised production.

Cover photo: Proton with an energy of 300 GeV producing 26 charged particles in the 30-inch hydrogen bubble chamber at the National Accelerator Laboratory, Batavia, Ill.

Copyright © 1970, 1974, and 1981 by John Wiley & Sons, Inc.

All rights reserved. Published simultaneously in Canada.

No part of this book may be reproduced by any means, nor transmitted, nor translated into a machine language without the written permission of the publisher.

*Library of Congress Cataloging in Publication Data:*

Halliday, David, 1916–

Fundamentals of physics.

Includes index.

1. Physics. I. Resnick, Robert, 1923– joint author. II. Title.

QC21.2.H35 1981 530 80-17184

ISBN 0-471-03363-4

Printed in the United States of America

10 9 8 7 6 5 4 3

## 29

Electromotive  
Force and Circuits

## 29-1 Electromotive Force

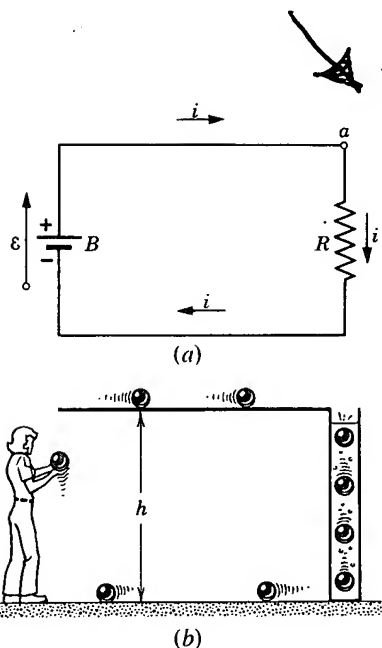


Figure 29-1 (a) A simple electric circuit and (b) its gravitational analog.

Definition of emf

There exist in nature certain devices such as batteries and electric generators that are able to maintain a potential difference between two points to which they are attached. We call such devices seats of *electromotive force* (symbol  $\epsilon$ ; abbr. emf). In this chapter we do not discuss their internal construction or detailed mode of action but confine ourselves to describing their gross electrical characteristics and to exploring their usefulness in electric circuits.

Figure 29-1a shows a seat of emf  $\epsilon$ , represented by a battery, connected to a resistor  $R$ . The seat of emf maintains its upper terminal positive and its lower terminal negative, as shown by the + and - signs. In the circuit external to  $\epsilon$  positive charge carriers would be driven in the direction shown by the arrows marked  $i$ . In other words, a clockwise current would be set up.

An emf is represented by an arrow that is placed next to the seat and points in the direction in which the seat, acting alone, would cause a positive charge carrier to move in the external circuit. We draw a small circle on the tail of an emf arrow so that we will not confuse it with a current arrow.

A seat of emf must be able to do work on charge carriers that enter it. In the circuit of Fig. 29-1a, for example, the seat acts to move positive charges from a point of low potential (the negative terminal) through the seat to a point of high potential (the positive terminal). This reminds us of a pump, which can cause water to move from a place of low gravitational potential to a place of high potential.

In Fig. 29-1a a charge  $dq$  passes through any cross section of the circuit in time  $dt$ . In particular, this charge enters the seat of emf  $\epsilon$  at its low-potential end and leaves at its high-potential end. The seat must do an amount of work  $dW$  on the (positive) charge carriers to force them to go to the point of higher potential. The emf  $\epsilon$  of the seat is defined from

$$\epsilon = dW/dq.$$

(29-1)